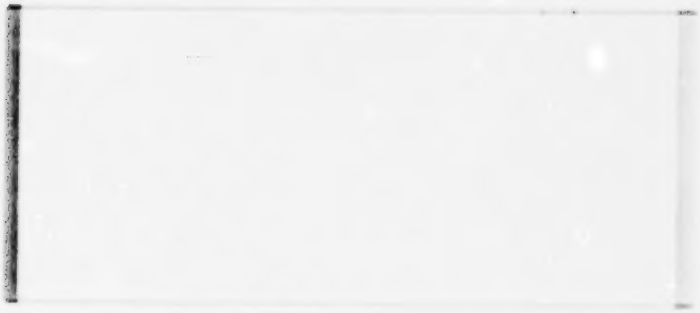

Saskatchewan

SENSITIVITY OF SASKATCHEWAN SURFACE WATERS TO ACIDIC INPUTS

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February, 1987

APC-39

ABSTRACT

An overview of the sensitivity of lakes in Saskatchewan to acidic deposition is presented, based upon criteria developed for alkalinity and calcium by the Coordinating Committee on Surface Waters for the Technical Committee for the Long Range Transport of Air Pollutants in Western and Northern Canada. Highly sensitive lakes are defined by the criteria as having an alkalinity value of less than 10 milligrams per litre (mg/L) or a calcium value of less than 4 mg/L. Moderately sensitive lakes are defined as having an alkalinity value between 10 and 20 mg/L, or a calcium value between 4 and 8 mg/L. The lower of the median calcium or median alkalinity value is used to determine a lake's sensitivity classification. Using these criteria, Saskatchewan Environment determined that generally, lakes on the Precambrian Shield area of northern Saskatchewan are classified as being either moderately or highly sensitive. The rest of Saskatchewan is well buffered against acid rain effects.

TABLE OF CONTENTS

	PAGE
ABSTRACT	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iii
1. INTRODUCTION	1
2. MAPPING LAKE SENSITIVITY	2
2.1 General Mapping Criteria	2
2.2 Lake Classification Criteria	3
3. MAPPING METHODOLOGY	4
3.1 Data Collection	4
3.2 Mapping Procedure	5
4. DISCUSSION	6
4.1 Alkalinity	6
4.2 Calcium	8
4.3 pH	10
4.4 Sensitivity Maps	10
5. SUMMARY	12
6. BIBLIOGRAPHY	13

LIST OF TABLES

TABLE		PAGE
1	Lake Classification Criteria	3
2	Lake Sensitivity Distribution Based on Alkalinity Values	7
3	Distribution of Lakes in High Sensitivity Category (Based on Alkalinity Values)	7
4	Lake Sensitivity Distribution Based on Calcium Values	9
5	Distribution of Lakes in High Sensitivity Category (Based on Calcium Values)	9

1.0 INTRODUCTION

In April 1981, the Technical Committee on Western Canada Long Range Transport of Atmospheric Pollutants recognized the need for a co-ordinated program in the four western provinces and the Northwest Territories to map the sensitivity of surface waters to acidic precipitation.

A Co-ordinating Committee on Surface Waters was established and charged with providing information on the status of sensitivity mapping in each region. The Committee was also asked to identify available information for a mapping program, to develop desirable parameters for mapping and to indicate information gaps.

The Co-ordinating Committee concluded that the variables chosen as indicators of lake sensitivity had to be common water quality parameters measured in western and northern Canada, had to be relatively free from potential error due to sampling and analytical techniques, and had to provide continuity with parameters used in earlier studies in Eastern Canada (Altschuller and McBean, 1979; Liaw and Alton, 1981; NRCC, 1981).

2.0 MAPPING LAKE SENSITIVITY

2.1 General Mapping Criteria

It must be recognized that sensitivity mapping, based upon lake data, soils data, surficial data or any other data is simply a planning tool at a macroscopic level. One of its uses can be in making decisions on the preliminary siting of proposed industrial operations. Such maps are not meant to replace site-specific assessments once one or several preliminary sites have been selected.

In preparing the lake sensitivity maps, Saskatchewan Environment followed the criteria established by the Co-ordinating Committee on Surface Waters. The criteria include the following:

- lake rather than river sensitivity should be mapped.
- discretionary use of river data could be made where appropriate coverage could not be derived from lake data provided the data represents geochemically homogenious watersheds.
- the parameters selected as the basis for mapping are alkalinity, calcium and pH.

- median values should be used for lakes with more than one measurement for a variety of depths, lake locations, seasons or periods in a season.
- only data collected since January 1977 are to be used to ensure recently developed analytical techniques were utilized and to ensure the maps reflected present lake sensitivity.
- the maps are to be drawn to a scale of 1:2,000,000.

2.2 Lake Classification Criteria

A set of criteria were established for calcium and alkalinity (Table 1) to form three sensitivity ranges (Saskatchewan Research Council, 1982).

TABLE 1 - LAKE CLASSIFICATION CRITERIA

	High Sensitivity	Moderate Sensitivity	Low Sensitivity
Calcium (Ca) (mg/l)	<4	4-8	>8
Alkalinity ($CaCO_3$) (mg/l)	<10	10-20	>20

By preparing two separate maps based upon available calcium and alkalinity data, a third sensitivity map based upon the two separate maps can be produced. To do this, the highest sensitivity rating for either of the two maps is used to determine an area's sensitivity rating. Thus, areas defined on either of the two maps as being of high sensitivity retain this classification on the third sensitivity map. This procedure allows all calcium and alkalinity data to be used, not just paired data sets.

3.0 MAPPING METHODOLOGY

3.1 Data Collection

The collection of data occurred in two phases. Phase One included the compilation of existing water quality (1977 and later) data for 260 Saskatchewan lakes. The data was obtained from existing Saskatchewan Environment water quality files, Parks and Renewable Resources fisheries files and from data collected for environmental impact baseline studies.

Phase Two consisted of a lake sampling program undertaken to augment existing data and to infill

areas which had not been sampled in the past. One hundred and sixty one (161) lakes were sampled between June 1983 and October 1985. Samples were collected near the water surface (0.3 metres) at the deepest point of the lakes.

3.2 Mapping Procedure

Upon completion of field work and compilation of historical data, all data were tabulated and summarized. Using this data, Environment Canada prepared the initial contour maps. Lines representing the appropriate contour intervals were plotted on maps using a computer program developed by the Federal Department of Energy, Mines and Resources, (General Purpose Contouring Program). The contours were then adjusted manually to remove any anomalies in the computer based maps. It should be noted that the contours were not plotted on a watershed basis. Such a delineation would have been too detailed for the map scale chosen (1:2,000,000) and also would have been inconsistent with work carried out in eastern Canada.

4.0 DISCUSSION

4.1 Alkalinity

Alkalinity values varied from a low of 0.5 milligrams per litre (mg/l) in northern Saskatchewan near Wollaston Lake to 4000 mg/l in a saline lake of southern Saskatchewan. Table 2 shows the distribution of the lakes in the various sensitivity ranges. Thirty-one (31) percent of the 420 lakes sampled were classified as highly sensitive (<10 mg/l), thirteen (13) percent were moderately sensitive (10 to 20 mg/l) and fifty six (56) percent of the lakes were in the low sensitivity range (>20 mg/l). Table 3 shows a further breakdown of lakes in the high sensitivity range.

There was a significant north-south variability in the alkalinity values. The majority of the lakes in the Precambrian Shield area of northern Saskatchewan were in the moderate to high sensitivity ranges. The lakes in the remainder of the province were classified as having a low sensitivity.

TABLE 2

LAKE SENSITIVITY DISTRIBUTION
BASED ON ALKALINITY VALUES

Lake Sensitivity	Number of Lakes in Each Range	Percent of Total Lakes Sampled
High Sensitivity (0 to 10 mg/l)	132	31
Moderate Sensitivity (10 to 20 mg/l)	54	13
Low Sensitivity (>20 mg/l)	234	56

TABLE 3

DISTRIBUTION OF LAKES IN HIGH SENSITIVITY
CATEGORY (BASED ON ALKALINITY VALUES)

Alkalinity Range	Number of Lakes in Each Range	Precent of Total Lakes in High Sensitivity Range
0 to 2.5 mg/l (0 to 50 ueq/l*)	13	10
2.6 to 5.0 mg/l (51 to 100 ueq/l)	30	23
5.1 to 7.5 mg/l (101 to 150 ueq/l)	36	27
7.6 to 10 mg/l (151 to 200 ueq/l)	53	40

* ueq/l is symbol for microequivalents per litre.

4.2 Calcium

Calcium values varied from a low of 0.3 mg/l in the Cree Lake area of northern Saskatchewan to 528 mg/l in the Radisson area of southern Saskatchewan. Table 4 shows the distribution of the lakes in the various sensitivity ranges. Fifty-two (52) percent of the 320 lakes* sampled were classified as highly sensitive (<4 mg/l), twelve (12) percent were classified as moderately sensitive (4 to 8 mg/l) and thirty-six (36) percent were in the low sensitivity range (>8 mg/l). Table 5 shows a further breakdown of lakes in the high sensitivity classification.

Lakes with low calcium levels (less than 8 mg/l) were primarily confined to the Precambrian Shield in northern Saskatchewan. Lakes with high calcium levels (greater than 8 mg/l) characterized the remainder of the province.

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* analyses for calcium were not conducted on as many lakes as for alkalinity. Alkalinity values were obtained for 420 lakes while calcium values were obtained for only 320 lakes.

TABLE 4

LAKE SENSITIVITY DISTRIBUTION BASED ON CALCIUM VALUES

Lake Sensitivity	Number of Lakes in Each Range	Percent of Total Lakes Sampled
High Sensitivity (0 to 4 mg/l)	166	52
Moderate Sensitivity (4 to 8 mg/l)	39	12
Low Sensitivity (>8 mg/l)	115	36

TABLE 5

DISTRIBUTION OF LAKES IN HIGH SENSITIVITY CATEGORY (BASED ON CALCIUM VALUES)

Calcium Range	Number of Lakes in Each Range	Percent of Total Lakes in High Sensitivity Range
0 to 1.0 mg/l (0 to 50 ueq/l*)	29	17
1.1 to 2.0 mg/l (51 to 100 ueq/l)	54	33
2.1 to 3.0 mg/l (101 to 150 ueq/l)	54	33
3.1 to 4.0 mg/l (151 to 200 ueq/l)	29	17

* ueq/l is symbol for microequivalents per litre.

4.3 pH

Plotting pH values indicated the state of acidity to date. Contour intervals representing every half pH values, i.e. 6.0, 6.5, 7.0, are plotted since no criteria existed to relate the present pH to sensitivity. However, it must be recognized that higher pH values would indicate areas less likely to be affected at an early date by acidic deposition.

The pH ranged from pH 5.10 in a small lake in the Wollaston Lake area of northern Saskatchewan to pH 9.50 in a highly alkaline lake in southern Saskatchewan. Sixty-nine (69) percent of the lakes sampled had a pH value greater than 7.0. The pH ranged from 6.0 to 7.0 in thirty-one (31) percent of the lakes sampled while pH values of less than 6.0 were found in less than one-half percent of the lakes. The lower pH ranges (less than pH 7.0) were found in the Precambrian Shield area. The regions of higher pH values (greater than pH 7.0) were found in southern Saskatchewan.

4.4 Sensitivity Maps

Sensitivity maps based on calcium, alkalinity, and combined calcium and alkalinity concentrations are found in the envelope located on the inside of the back cover of this report. A map showing present lake acidity (pH contours) is also included.

The maps indicate the northern third of the province is very sensitive to acidic deposition. This area of the province is precambrian in orgin. A survey conducted by Saskatchewan Parks and Renewable Resources in November, 1985, estimated that 83,500 lakes (52,850 km^2) are located in the Precambrian Shield and the Shield boundary area (A. R. Murray, 1985). This represents eighty-nine (89) percent of the 94,057 lakes in the province. Hendrey et al. (1979) and Norton (1980) classified geologic areas like the Precambrian Shield as highly to moderately sensitive to acidic deposition. This area is comprised of the Athabasca Plains and the Precambrian basement. The Athabasca Plains, a large oval area underlying a significant portion of northern Saskatchewan, is composed of coarse grained quartzitic sandstones overlain by sandy drift. The bedrock and overlying materials have minimal buffering capacity and lakes in this area are classified as moderately to highly sensitive to acidic inputs. The Precambrian basement rocks surround the Athabasca Plains and underlie the remainder of northern Saskatchewan. They are primarily composed of granitic-plutonic rocks, granite gneisses, and softer metasediments; overlying materials consist of thin organic layers. Many of the soils in these regions are acidic and have low buffering capacity (Shewchuk et al 1981).

The sensitivity maps also indicate that the lakes located in the remaining regions of Saskatchewan are generally well buffered and hence rather insensitive to the effects of acidic deposition. An estimated 10,558 lakes (11 percent of the total) are located in the southern two-thirds of the province (A. R. Murray, 1985). The presence of carbonate-rich bedrock overlain by glacial tills and outwash material is reflected in the high alkalinity and calcium values of lakes in these regions.

5.0 SUMMARY

Using the criteria developed by the Coordinating Committee on Surface Waters for alkalinity and calcium, it was determined that generally lakes on the Precambrian Shield area of northern Saskatchewan are classified as highly sensitive to acidic inputs. Lakes in a narrow band along the south and west perimeter of the Precambrian Shield (Shield boundary) are classified as moderately sensitive. The rest of Saskatchewan is well buffered and lakes in this area have a low sensitivity to acidic inputs.

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